

行動資訊服務環境技術之研究與製作-警政資訊系統的應用(III):

子計劃五:行動資訊服務環境下網路精靈之研究與製作(III)

Research and Design of Ubiquitous Information Service Environments(III)
-Intelligent Messaging for Ubiquitous Information Service Environments(III)

計劃編號: NSC 88-2113-E004-003

執行期限: 87/08/01~88/07/31

主持人: 連耀南 國立政治大學資訊科學系教授

電話:(02)29387544, 29393091 ex62275, FAX:(02)22341494

E-mail:lien@cherry.cs.nccu.edu.tw HomePage:http://www.cs.nccu.edu.tw/~lien

中文摘要

網際網路上豐富的資訊資源提供了未來資訊化社會中資訊使用者隨手可得的資訊寶藏。除了高速網路以及資料庫的建造之外,如何使這種資訊資源也能很方便的提供給行動中的使用者,使得資訊資源真正成為無遠弗屆,讓使用者隨時隨地很方便的擷取並運用所需的資訊,已成為資訊界最重要的課題之一。

行動資訊網路上主要的技術障礙是:通訊頻寬太低,通訊品質不佳、通訊費用高昂、以及作業環境的複雜。網路精靈(或智慧型訊息)是克服這些困難的的關鍵技術之一,網路精靈是一種帶有程式的網路訊息,可以依據程式中的指令巡航於網路中執行指定的任務。行動中的使用者,可以藉由網路精靈以極低的代價很方便的到網路上擷取並運用網路上的資訊資源。

目前學術界中大部份的研究重點,多集中於行動通訊各項技術以及網路精靈的功能的研究,而在資訊服務環境的技術則鮮少著力。本計畫在研究於網路精靈的模式下提供資訊服務所需的關鍵技術。其目標是要提供一個環境,讓行動式資訊服務的提供者,在開發完成服務邏輯之後,能很快很方便的建置於網際網路中。

在本計畫的支持下,我們設計了一個開放式整體服務網路架構,本架構的特色是:

- (一) 實體的傳輸網路必須與邏輯網路(服務網)分離,
 - (二) 採用開放式的架構,
 - (三) 服務網之加入、退出、與營運採用分散式管理,避免中央集中管理。
- 本計畫並根據所設計的架構設計建造一個運用網路精靈的行動資訊服務雛形系統,包含以下各主要系統:
- (一) 網路精靈伺服器設計、
 - (二) 各種網路精靈搜尋程式設計、
 - (三) 網路精靈程式語言設計、
 - (四) 管理系統。

我們利用 email 的機制完成了名為「勛斗雲」的雛形系統的設計與建構,提出了一種 script-

rewriting 的技術,供網路精靈在不同的伺服器間輾轉傳送,並設計了一個專供網路精靈的設計者使用的 Script Language。

在網路精靈的控制與搜尋方面,我們設計並建造了一個完整的管理系統,並提出一個新的控制功能 look-forward control,供管理者在網路精靈尚未到達預定的伺服器前即可預設控制指令,以增加管精靈的靈活性。

為了要管理網路精靈,管理者必須獲得精靈的位置。我們提出了許多不同的方法,並對具循序特性的精靈搜尋方法做了深入的研究,提出了數種搜尋方法,可以提高搜尋的效率。

關鍵詞: 智慧型訊息, 網路精靈, 行動計算, 資訊服務

1. Abstract

To make information ubiquitously available to the people in the world requires not only the Information Superhighway, it also requires a new computing paradigm to overcome the intermittent connection problem inherent in mobile environments as well as many commercially viable service networks providing various information services to the users. In this three year research, we had proposed an open architecture that allows new services and facilities be easily added into networks, and have designed and implemented a prototype of mobile agent service network on top of that architecture. The users of a mobile agent service network can submit a mobile agent to the network performing tasks on behalf of the user. Our researches mainly focus on the issues regarding to the operation, administration, and maintenance (OA&M) which are critical components of a service network.

We have developed a prototype of such a service network, FlyingCloud, in NCCU. FlyingCloud uses email as the underlying transport mechanism. We also designed a script-based programming language which is very easy to learn and to use as compared with java-based languages. Finally, we have implemented a management system for system administrators to manage agents. Among the popular controlling mechanisms, we

have proposed a unique control feature, look-forward control, which allows a manager to preset a control message in a server where the targeted agent haven't reach the server yet. We also have designed several search algorithms to help system administrators to locate a mobile agent. Among them, we deeply studied several sequential search algorithms which can greatly enhance the efficiency of agent search.

KEY WORDS: Mobile Computing, Mobile Agent.

1. Introduction

To make information ubiquitously available to the people in the world requires not only the Information Superhighway, it also requires a new computing paradigm to overcome the intermittent connection problem inherent in mobile environments as well as many commercially viable service networks providing various information services to the users [1].

Most current researches in mobile computing area are mostly focusing on the functionality of the system, such as the intelligent capability of an agent. The service infrastructure and the management issues do not get much attention from researcher in this area. We strongly believe that these issues are more or equally important than the functional capability of a mobile computing system. Therefore, we take the pioneering position to initiate this research.

2. Research Results

In our previous research, we had proposed an open architecture that allows new services and facilities easily be added into networks, and a mobile agent service network on top of that architecture [2,3]. The users of a mobile agent service network can submit a message containing an executable script to the network performing tasks on behalf of the user. Our researches focus on the issues regarding to the operation, administration, and maintenance (OA&M) which are critical components of a service network. We have been developed a prototype of such a service network, FlyingCloud, in NCCU [8,10,11,15]. The FlyingCloud will facilitate further study on various OA&M issues that are special to this new computing paradigm. The agent in FlyingCloud is autonomous and self-contained. After being submitted to the network, it can be executed by a sequence of servers one-by-one. A server can execute the agent and forward it to the next one according to the script carried by the agent. Different from the RPC (Remote Procedure Call) approach, the execution of an agent in each server is atomic so that the control of an agent in a server is completely released after the agent moves to another server [14].

We have designed a script language allowing users to specify their demands [8,10,11,15]. We proposed the "script-rewriting" technique for environment migration. When an agent is moving from one server to another, the

agent is wrapped together with its execution environment into another agent and is then forwarded to the next server. The receiving server can execute the agent as if it is a new agent to recover the execution environment [8,10,11,15]. This "script-rewriting" technique is particularly good for heterogeneous environment where "image-copying" approach is difficult to apply.

One basic OA&M function for a mobile agent service network is the control of the agent. We have defined a "finite state machine" to represent the life-cycle of an agent and several new control functions which have not been seen in any other computing environment.

Tracking the location of agents is another critical problem in managing a service network. One class of strategies is to have the target agent report its locations periodically so that it can be located immediately. To avoid the unnecessary messages for location reporting, another class of strategies searches the target agent "on-demand", at the cost of paying extra searching time. In our research, we have developed several search strategies corresponding to various situations [7,12,18,19,20,22]. Most search strategies are a variation of the Basic Binary Search (BBS) which is very similar to the conventional binary search algorithm used to locate a data object in a sorted array. Unfortunately, BBS may fail to locate a target agent because the target agent is moving and may "slip-through" the search window. Thus, We proposed the Extended Binary Search (EBS) to correct the problem.

To further reduce the number of search probes, we then proposed several other search algorithms to enhance the EBS. In the case when the service time of each server on the network is statistically predictable, the number of search probes can be further reduced by predicting the current location of the target agent using service time statistics. Based on this technique, we proposed the Intelligent Search strategies and several formula which can closely predict the location of the target agent.

We also found that in the EBS search algorithm, the forward and backward search probes are treated quite differently such that probing a node that has been visited by the target agent will result in cutting more node out of the search list. Therefore, the best range to probe is not necessarily at the middle of the search list. In our study, we found that the best range to probe is between 0.29 and 0.4 of the search list starting from the head. Based on this study, we have designed some static and dynamic asymmetric binary search algorithms to take this advantage to improve the search speed.

Another area to improve is the adaptivity. During the search, the search agent can actually use the most current information of the target agent That is available in the probed nodes such as the departure time. This information can be used in several different ways:

1. In Intelligent Search, the search agent can use the updated departure time to recalculate the resident probability of each node to gain a more accurate

prediction on the current location of the target agent.
2. In the Extended Binary Search, the search agent can switch to another search algorithm based on this information. For instance, if the target agent just left the currently probed node not long ago, the target agent can switch to the sequential search immediately, instead of proceeding with the original binary search.

Based on this study, we have designed several adaptive search algorithms. The main research challenges are as follows:

1. How to predict the current location of the target agent?
2. How to estimate the prediction error?
3. What is the best gambling rule that can help users to reduce the penalty due to the prediction error?

3. Project Evaluation

3.1 Results vs. Expectation

We have successfully implemented a prototype of the mobile agent service networks. We also have designed several good search algorithms. We also apply some research results in the design of Police Mobile Information System. The results are beyond our expectation.

3.2 Significance of the Results

Our prototype, "FlyingCloud", is the first system to support mobile computing in Taiwan and is one of the first in the world. Some of our approaches, such as script rewriting for agent environment migration, are the first of its kind. Our research is the first in the world to deal with the operation, administration, and maintenance problems of a mobile agent service system. We have that opportunity to take leading position in this research area.

The research in agent search is also taking leading position in the world.

3.3 Applicability the Industry

Our research results can be applied to many applications particularly on top of our Hybrid Ad Hoc Mobile Computer Network, which is a undergoing research targeted to support disaster field management system, such as the an earthquake disaster. In such disaster situations, all wide area communication systems may be broken as we have seen in the recent 921 Earthquake event. Our Hybrid Ad Hoc Mobile Computer System doesn't rely on external wireless communication support and is a very good system to support disaster field management.

3.4 Publications

The results of our research has been published in various academic conferences [1-36].

3.5 Patentable Results

Many of our search algorithms and original designs are patentable.

3.6 Student Training

Many senior students were involved in this projects. All of them received a very good training from this project. Many of them are coauthors of a number of papers published in academic conferences [5,6,8,10,12,14,15,18,19,20,22]. Mainly due to their outstanding achievements in this project, several of them had been admitted to the Graduate School of some universities including National Taiwan University, UIUC, UT Austin, etc.

The most outstanding one is the coauthor of more than ten papers and is admitted to the graduate school of University of Wisconsin, Madison with research assistantship.

Reference

1. Yao-Nan Lien, "Perspective of Service Networks on National Information Infrastructure", CCL Technical Journal, no. 35, Dec. 1, 1994, pp. 28-36.
2. Yao-Nan Lien, "An Open Intelligent Messaging Network Infrastructure for Ubiquitous Information Service", Proc. of First Workshop on Mobile Computing, April. 1995, pp. 2-9.
3. Yao-Nan Lien, "Client and Agent Mobility Management", Proc. of the 2nd International Mobile Computing Conference, Mar. 1996, pp. 141-151.
4. Wen-Shyen Chen and Yao-Nan Lien, "Intelligent Messaging for Mobile Computing over the World-Wide-Web", Proc. of the 2nd International Mobile Computing Workshop, Mar. 1996, pp. 42-51.
5. Yao-Nan Lien, Yenlin Yin, Fuhua Liu and Yuli Hwang, "A Mobile Agent Service Network Prototype", Proc. of 1996 Workshop on Distributed System Technology and Applications, May 1996, pp. 278-286.
6. Wen-Shyen Chen, Yao-Nan Lien and Wen-Yee Hsien, "An Infrastructure for Mobile Computing with Intelligent Messaging: Implementation Issues", Proc. of 1996 Workshop on Distributed System Technology and Applications, May 1996, pp. 270-277.
7. Yao-Nan Lien and Chun-Wu R. Leng, "On the Search of Mobile Agents", Proc. of The 7th IEEE International Symposium on Personal, Indoor, and

Mobile Radio Communications (PIMRC'96) , Oct. 1996, pp. 703-707.

8. Yao-Nan Lien, Yenlin Yin, Chin-Hung Chen, Fuhun Liu and Yuli Hwang, "FlyingCloud: A Mobile Agent Service Network", Proc. of the International Conference on Distributed Systems, Software Engineering, and Database Systems , Dec. 1996, pp. 129-136.
9. Yao-Nan Lien, "Ubiquitous Information Service Environments", Proc. of 1997 Workshop on Internet Technology and Applications , Jan. 28. 1997, pp. A1.1-1-A1.1-25.
10. Yao-Nan Lien, Yenlin Yin, Chin-Hung Chen, Fuhun Liu and Yuli Hwang, "The Design of FlyingCloud: A Mobile Agent Service Network", Proc. of the 3rd Workshop on Mobile Computing , March 1997, pp. 53-60.
11. Wen-Shyen Chen, H. T. Shu, S. T. Su, C. H. Du and Y. N. Lien, "An Open Infrastructure for Mobile Agents in Mobile Computing", Proc. of the 3rd International Mobile Computing Workshop , March 1997, pp. 61-67.
12. Yao-Nan Lien, Fuhun Liu, Chun-Wu Leng and Wen-Shyen Chen, "Intelligent Search of Mobile Agents", Proc. of the 1997 International Conference on Computer System Technology for Industrial Applications , April, 1997, pp. 110-116.
13. Hung-Chin Jang, Yao-Nan Lien and Shih-Shyan Huang, "Client Mobility Management on Ubiquitous Information Service Networks", Proc. of the 1997 Workshop on Distributed System Technology and Applications , May 1997, pp. 325-338.
14. Yao-Nan Lien, Yenlin Yin and Tony Chan, "Design of Mobile Agent Servers", Proc. of the 1997 Workshop on Distributed System Technology and Applications , May 1997, pp. 339-346.
15. Yao-Nan Lien, Yenlin Yin and Tony Chan, "Issues and Design of Server for FlyingCloud - A Mobile Agent Service Network", Proc. of the Third Workshop on Real-Time and Media Systems , July 1997, pp. 237-242.
16. Hung-Chin Jang, Yao-Nan Lien and Jyh-Shyan Huang, "Client Location Tracking with K-Step Prediction and Cache Policy in Ubiquitous Information Service Network", Proc. of Asia Pacific Software Engineering Conference and International Computer Science Conference, Hong Kong , Dec. 2-5, 1997.
17. Hung-Chin Jang, Yao-Nan Lien and Jyh-Shyan Huang, "Client Location Tracking in Ubiquitous Information Service Network", Proc. of 1997 International Conference on Parallel and Distributed Systems, Seoul, Korea , Dec. 11-13, 1997.
18. Yao-Nan Lien, Fuhun Liu, Wen-Shyen Chen and Chun-Wu Leng, "Asymmetric Binary Search of Mobile Agents ", 1997 International Symposium on Multimedia Information Processing , Dec. 1997, pp. 294-299.
19. Yao-Nan Lien, Fuhun Liu, Wen-Shyen Chen and Chun-Wu Leng, "Adaptive Search of Mobile Agents ", Proc. of 1997 National Computer Symposium , Dec. 1997, pp. 95-100.
20. Hung-Chin Jang, Yao-Nan Lien, Jyh-Shyan Huang and Fuhun Liu, "Non-Deterministic Binary Search of Mobile Agents ", Proc. of 1997 National Computer Symposium , Dec. 1997, pp. 89-94.
21. Yao-Nan Lien, "FlyingCloud: A Prototype of Mobile Agent Service Networks", Proc. of 1997 Agent Technology Workshop , Dec. 1997.
22. Hung-Chin Jang, Yao-Nan Lien, Jyh-Shyan Huang and Fuhun Liu, "New Intelligent Search of Mobile Agents", Proc. of 1997 Agent Technology Workshop , Dec. 1997.
23. Wen-Shyen Chen, H.-T. Shu, S.-T. Su and Yao-Nan Lien, "Mobility and Management Support for Mobile Agents In Mobile Computing Environments", Proc. of 1997 Agent Technology Workshop , Dec. 1997.
24. Wen-Shyen Chen, Chun-Wu R. Leng and Yao-Nan Lien, 1997, "A Novel Mobile Agent Search Algorithm", Proc. of the International Conference on Computer, Communications and Networks, Sep. 1997, pp. 128-131.
25. Hung-Chin Jang and Yao-Nan Lien, 1998, "Multiple Network Management Centers for Managing Client Mobility ", Proc. of The Twenty-Second Annual International Computer Software and Applications Conference (COMPSAC'98).
26. Hung-Chin Jang, Yao-Nan Lien and Jyh-Shyan Huang, 1998, "Using Cut Vertics Search to Search Mobile Agents on a Non-Deterministic Path", Proc. of the 4rd Workshop on Mobile Computing , March 1998, pp. 7-14.
27. Wen-Shyen Chen, Yao-Nan Lien and Huiling Liu, 1998, "A Mobile Raytracing Agent for Internet

Computing", Proc. of the 4rd Workshop on Mobile Computing , March 1998, pp. 86-93.

28. Yao-Nan Lien, 1998, "Design of FlyingCloud - A Mobile Agent Service Network", Proc. Of the 1998 International Conference on Advanced Science and Technology, April 1998, pp.17-28.
29. Yao-Nan Lien, 1998, "Search of Mobile Agents", Proc. of the 15th on Combinatorial Mathematics and Computation Theory Workshop , April 1998, pp. 76-79, NSC Grant (87-2213-E-004-002).
30. Yao-Nan Lien, Hung-Chin Jang, Tzu-Chieh Tsai and Wen-Shyen Chen, 1998, "Network Architecture for a Mobile Police Information System (MPIS)", Proc. of the 1998 Workshop on Distributed System Technology and Applications, May 1998, pp. 511-516, NSC Grant (87-2213-E-004-002).
31. Hung-Chin Jang, Yao-Nan Lien and Jyh-Shyan Huang, 1998, "A New Network Management Scheme for Managing Client Mobility", Proc. of The 1998 International Symposium on Internet Technology, April 1998, pp. 154-159, NSC Grant (87-2213-E-004-002).
32. Wen-Shyen Chen, S. T. Su, Yao-Nan Lien, H. T. Su and Huiling Liu, 1998, "Mobility and Management Support for Mobile Agents", Proc. of the 2nd International Conference on Autonomous Agents, May 1998, pp. 451-452.
33. Yao-Nan Lien, Tsu-Chieh Tsai, Hung-Chin Jang and Wen-Shyen Chen, "Architecture and Research Issues of a Hybrid Ad-Hoc Mobile Computer Network", Proc. of the 5th Workshop on Mobile Computing, March 1999.
34. Tsu-Chieh Tsai, Yao-Nan Lien, Hong Chang Chiu, Shi-Chi Huang, Kenex Huang, Hung-Kai Ting and Jia-Xin Yang, "Network Issues and Implementation for a Mobile Police Information System (MPIS)", Proc. of the 5th Workshop on Mobile Computing, March 1999.
35. Hung-Chin Jang, Yao-Nan Lien and Jyh-Shyan Huang, "Client Mobility Management for Hybrid Ad Hoc Mobile Computer Network", Proc. of the 5th Workshop on Mobile Computing, March 1999
36. Hung-Chin Jang, Yao-Nan Lien and Jyh-Shyan Huang, "A Study on Client Mobility Management for Ubiquitous Information Service Network", Proc. of the 1999 Workshop on Distributed System Technology and Applications, May 1999.